Soil Organic Matter Stratification with Depth under Pastures in the Southern Piedmont USA

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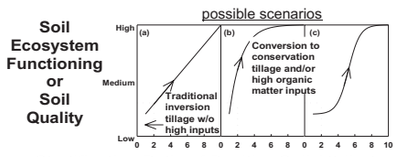
RATIONALE

Soil quality is a concept based on the premise that management can deteriorate, stabilize, or improve soil ecosystem functions.

Soil organic matter is a key component of soil quality that sustains many key soil functions by providing the energy, substrates, and biological diversity to support biological activity, which affects
(1) aggregation (important for habitat space, oxygen supply, and preventing soil erosion),
(2) infiltration (important for leaching, runoff, and crop water uptake), and
(3) decomposition (important for nutrient cycling and detoxification of amendments).

Degree of stratification of soil organic C and N pools with soil depth, expressed as a ratio, could indicate soil quality or soil ecosystem function. Stratification ratios would allow a wide diversity of soils to be compared on the same assessment scale because of an internal normalization procedure that accounts for inherent soil differences.
Franzluebbers AJ. 2002. Soil organic matter stratification ratio as an indicator of soil quality. *Soil & Tillage Research* 66:95-106.

Grass-based agricultural systems may improve soil quality and this could be recognized by high stratification ratios.



OBJECTIVES

(1) Determine the effect of various forage and pasture management strategies on the stratification of soil organic C and N with soil depth
(2) Identify the most dynamic soil C and N components that respond to management

MATERIALS and METHODS

Environment

16.5 ˚C annual temperature
125 cm annual precipitation
165 cm annual evaporation

Soils

clayey, kaolinitic, thermic
Typic Kanhapludults

Management comparisons

1 Grazed K-31 tall fescue-common bermudagrass pasture (20-yr old) versus adjacent conservation-tillage cropland (24-yr old)
2 Grazed versus hayed bermudagrass (15-19-yr old 'Coastal' and 'Tifton 44', 3 fields each)
3 Chronosequence of K-31 tall fescue (10, 17, and 50-yr old) and of 'Coastal' bermudagrass (6, 12, and 40-yr old)
4 Long-term land uses of 24-yr-old conservation-tilled cropland, 40-yr-old hayed bermudagrass, 50-yr-old grazed tall fescue, and 130-yr-old forest
5 Degraded cropland converted to 'Coastal' bermudagrass with yearly evaluation during 5 years of:
Fertilization (214 kg N/ha/yr) - (a) inorganic only, (b) clover + inorganic, and (c) broiler litter
Harvest strategy - (a) unharvested, (b) low grazing pressure (3 Mg forage/ha), (c) high grazing pressure (1.5 Mg forage/ha), and (d) hayed

Analyses

Soil organic C and N by dry combustion (Leco CNS 2000)
Particulate organic C and N collected on 0.05 mm screen following dispersion and analysis with dry combustion
Non-particulate organic C and N as difference from total
Soil microbial biomass C with chloroform fumigation-incubation without subtraction of control
C mineralization from incubation at 50% water-filled pore space and 25 ˚C for 24 days

Stratification calculation

Concentration at 0-5-cm depth divided by the concentration at 12.5-20-cm depth (Mgt 1-4) and 0-2 / 4-6 cm (Mgt 5)

RESULTS

* is $p \leq 0.1$ and ** is $p \leq 0.01$
ns is not significant

Management comparison 1


Stratification ratio of (0-5 cm) / (12.5-20 cm):	Conservation tillage		Tall fescue pasture
Soil organic C	3.5	ns	4.0
Particulate organic C	6.2	**	11.5
Soil microbial biomass C	3.1	ns	2.6
Potential C mineralization	25.5	ns	20.6

Management comparison 2


Stratification ratio of (0-5 cm) / (12.5-20 cm):	Grazed		Hayed
Soil organic C	6.0	ns	4.9
Particulate organic C	18.0	**	11.5
Soil microbial biomass C	3.7	ns	3.3
Potential C mineralization	17.4	ns	20.4

Management comparison 3

Stratification ratio of (0-5 cm) / (12.5-20 cm):	Hayed bermudagrass chronosequence 6 yr	12 yr	40 yr	
Soil organic C	4.3	3.7	6.8	*
Particulate organic C	8.4	10.2	10.5	ns
Soil microbial biomass C	3.2	2.9	4.2	*
Potential C mineralization	24.4	15.7	12.6	*

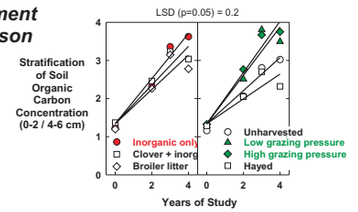
	Grazed tall fescue chronosequence 10 yr	17 yr	50 yr	
Soil organic C	4.7	5.0	7.5	*
Particulate organic C	12.3	11.0	17.8	*
Soil microbial biomass C	3.8	3.0	5.2	*
Potential C mineralization	20.4	16.3	15.9	ns

Management comparison 4




Stratification ratio of (0-5 cm) / (12.5-20 cm):	LSD (p=0.05)	Cropland	Hayland	Grazingland	Forestland
Soil organic C	2.0	3.5	**6.8**	**7.5**	3.9
Particulate organic C	4.1	6.2	10.5	**17.8**	4.2
Soil microbial biomass C	1.4	3.1	**4.2**	**5.2**	2.7
Potential C mineralization	13.4	25.6	12.6	15.9	13.0

Management comparison 5



Sensitivity of soil properties to stratification was evaluated during the first 4 years of management, by comparing F-values (ratio of known-to-unknown variability). Highest F-values indicate the greatest sensitivity.

Soil microbial biomass C	4.3 a	Potential N mineralization	3.1 abc
Particulate organic N	3.5 ab	Potential C mineralization	3.1 abc
Particulate organic C	3.5 ab	Soil inorganic N	2.3 bc
Total organic C	3.4 ab	Flush of CO2 in 3 days	2.2 bc
Total soil N	3.2 abc	Non-particulate organic N	1.7 bc
Soil bulk density	3.1 abc	Non-particulate organic C	1.4 c

At the end of 5 years of management

Stratification ratio of (0-6 cm) / (12-20 cm):	LSD (p=0.05)	Un harvested	Grazing: Low Pressure	Grazing: High Pressure	Hayed
Soil organic C	0.7	3.4	3.6	3.6	**2.7**
Total soil N	1.7	6.7	7.1	7.3	**5.3**
Bulk density	0.04	0.77	0.77	0.82	**0.83**

SUMMARY

Stratification of soil properties with depth is a consequence of conservation management that supplies organic residues at the soil surface resulting in:
- protection of the soil surface from erosion
- concentration of substrates to enhance biodiversity
- development of biologically supported physico-chemical processes (e.g., aggregation, nutrient cycling)

Land management with cattle grazing resulted in stratification ratios that were as high or higher than:
- conservation-tillage cropland
- haying to remove grass without animal traffic
- natural forestland

Soil organic C and N pools became quickly stratified under pastures following conversion from degraded cropland

Many soil properties become stratified under pasture management strategies; ***Total, particulate, and microbial biomass C pools were equally sensitive*** to management-controlled changes in stratification

Prediction of optimum soil quality with stratification ratios is still premature, but the average soil organic C stratification ratio of 5 under the various pasture systems evaluated here might be a reasonable target

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